

Next Generation Turbine Program



Turbine Power 2000

November 13, 2000

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National Energy Technology Laboratory





Strategic Center for Natural Gas

“... I am also announcing today that I will establish, within this facility, a new Center for Advanced Natural Gas Studies.”

“We need one place that looks out for the future of natural gas -- from borehole to burnertip. One place that understands the innovations needed to produce tomorrow's gas.”

“In other words, we need a strategic center that looks at the big picture and devises the bold ideas that allow the FULL potential of natural gas to be achieved. And I want that center to be located at this Laboratory.”

*Bill Richardson, Secretary of Energy
December 10, 1999*



Strategic Center for Natural Gas

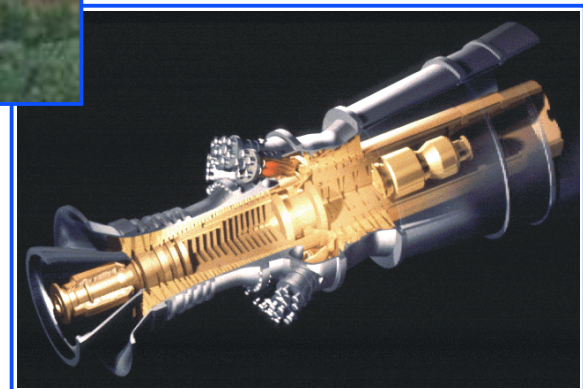


Affordable supply



Reliable delivery

**Clean, efficient
utilization**



Strategic Center for Natural Gas

Vision:

By 2020, U.S. Public is enjoying benefits from an increase in gas use:

- Affordable supply
- Reliable delivery
- Environmental protection



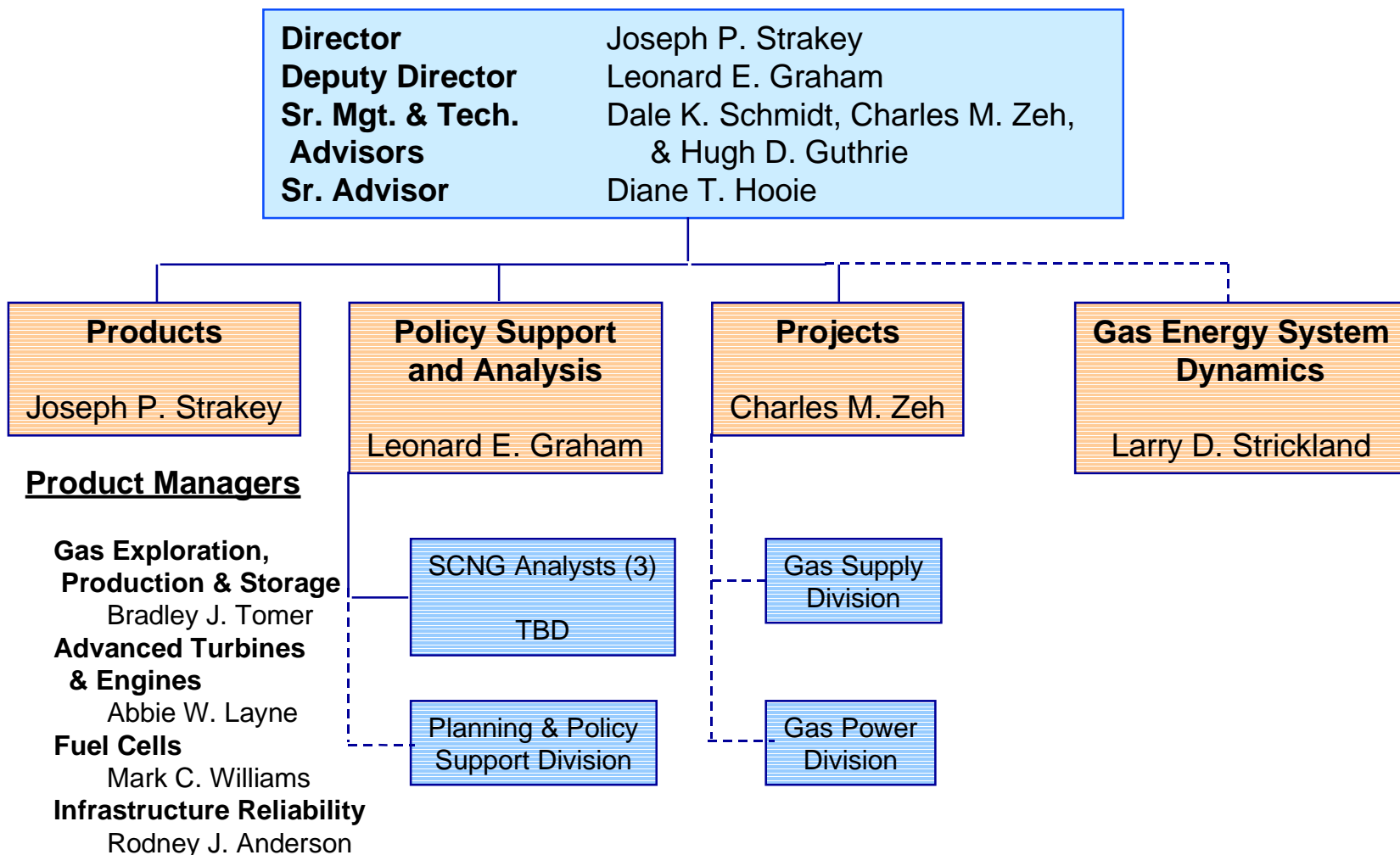
Mission:

Be the focal point for an integrated gas program:

- Spearhead annual DOE-wide gas RD&D planning and program assessment
- Provide science and technology advances through NETL's on-site programs
- Shape, fund, and manage extramural RD&D
- Conduct studies to support policy development



Strategic Center for Natural Gas



Power World of Tomorrow



*Power industry
deregulation across
United States*



*Environmental
Demands
Escalating*

300 GW Power Demand

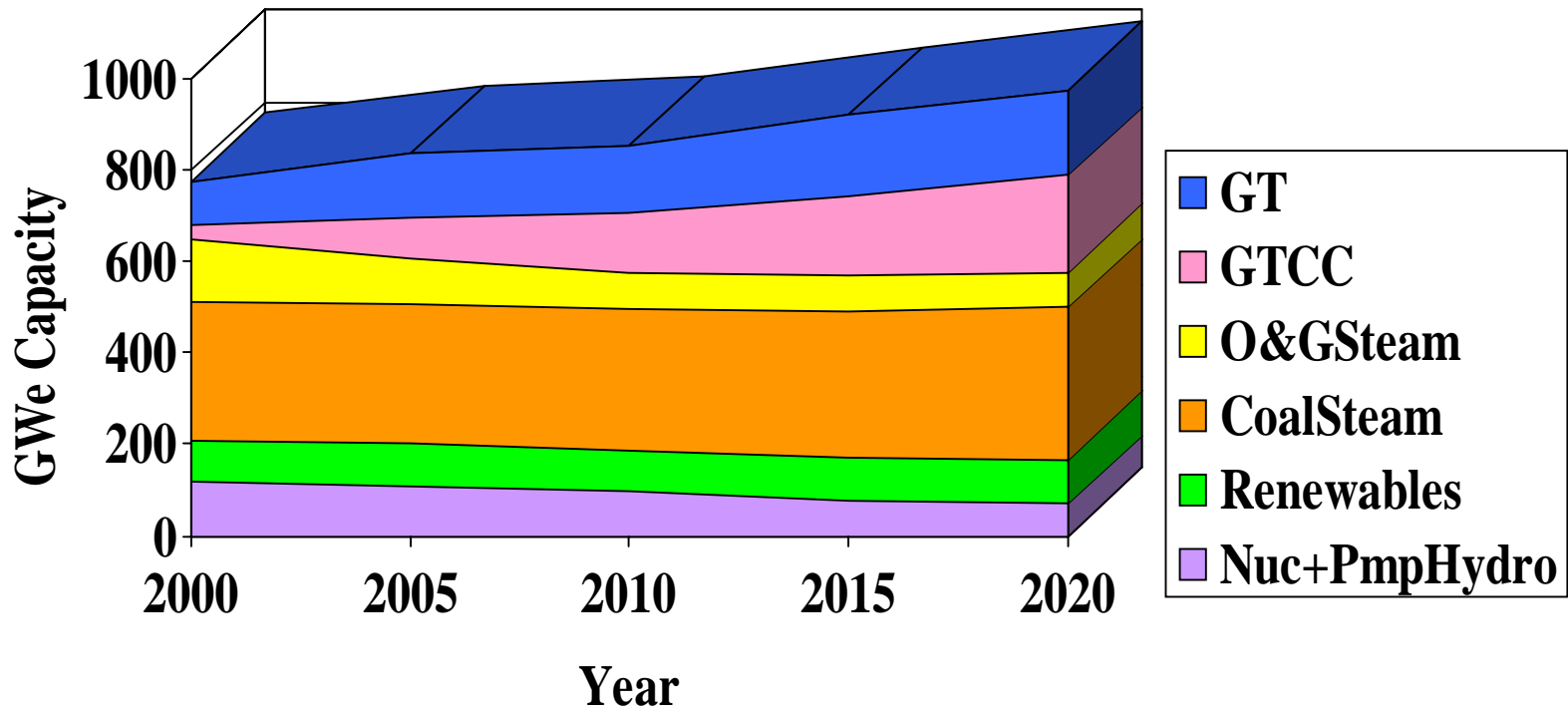
- Large Gas Turbine Plants*
- Distributed Power*

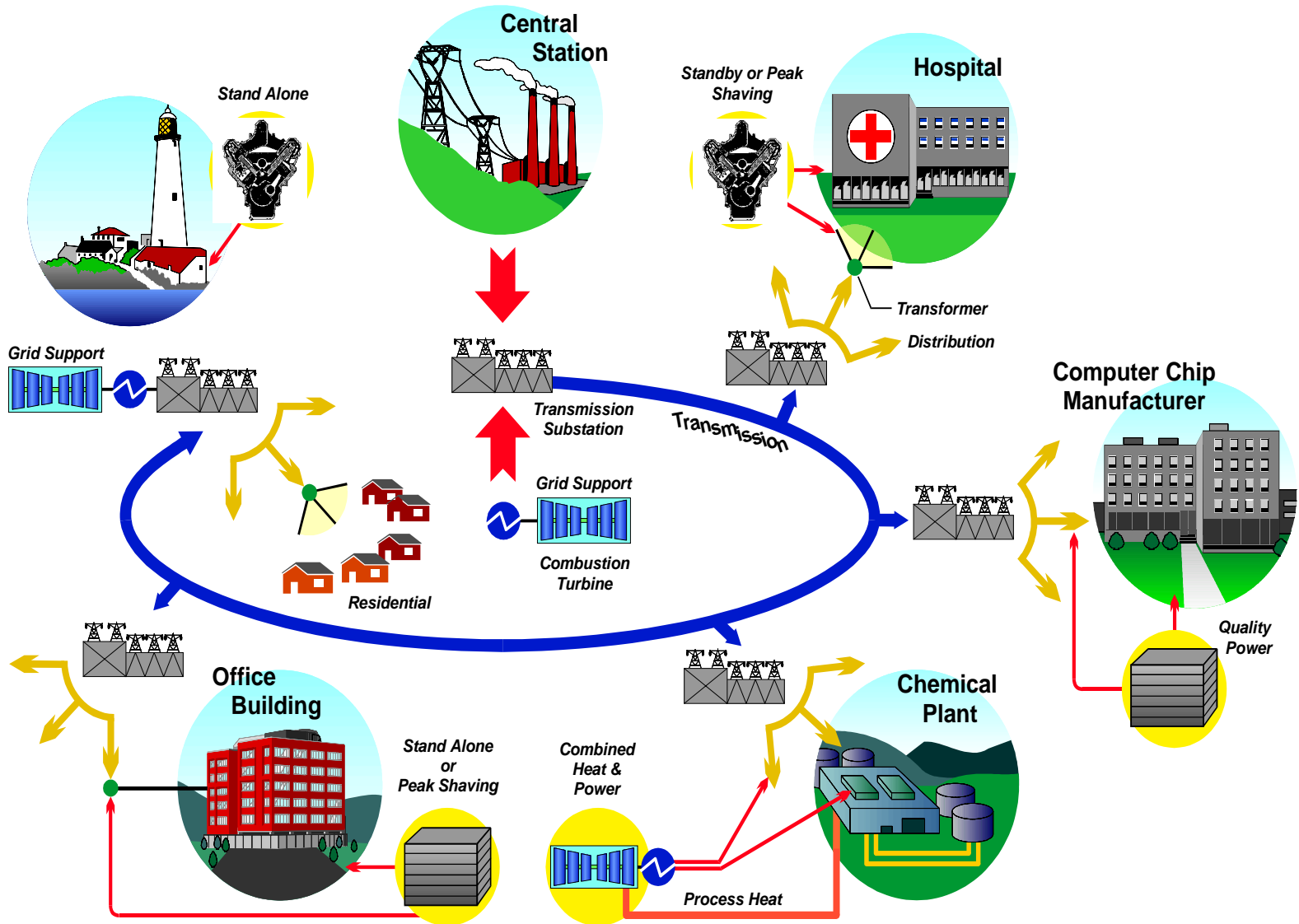


U.S. Electric Generation Capacity over Time

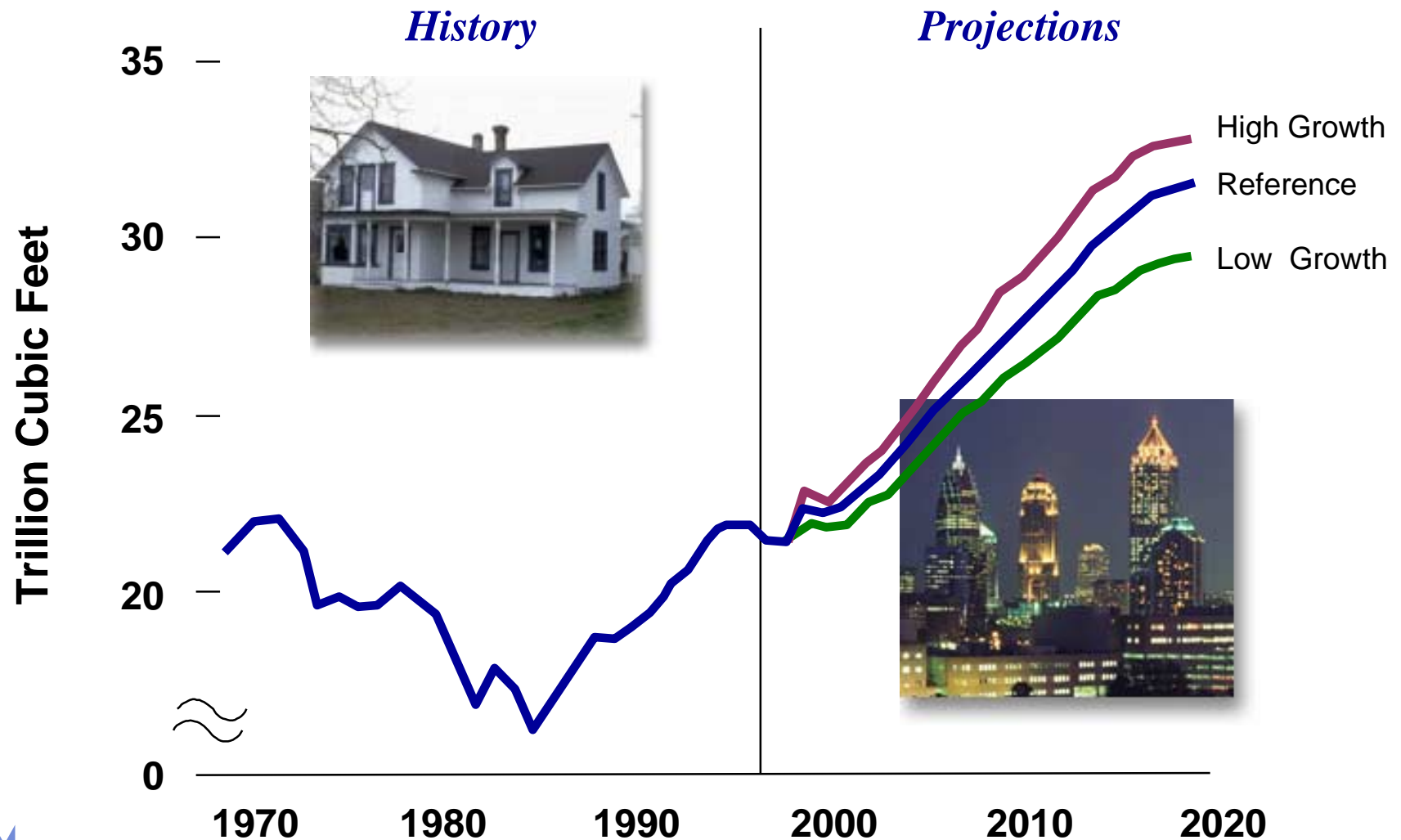
Source: DOE-EIA Annual Energy Outlook, 2000

Electric Generating Capacity





Significant Increase in Natural Gas Consumption



Source: Annual Energy Outlook 2000, Figure 92

ATS Program Objectives

By 2000, develop advanced turbines that are:

- **Ultra-high efficiency:** **>60% for utility-scale systems**
15% improvement for industrial- scale systems
- **Super-clean:** **NOx <10 ppm**
- **Cost of electricity:** **10% less**
- **Fuel-flexible:** **gas is primary focus**

Leapfrog in Turbine Performance



Advanced Turbine Systems *System*

Development and Testing

- **ATS utility scale products are the cleanest, most efficient gas turbine power plants in the world**
- **Scheduled for demonstration near Scriba, New York and Orlando Florida during the year 2002**
- **Over 95 universities, DOE national labs and US industries partnered to develop ATS**



Drivers for Continuing Government Investment in Gas Turbines

- **Growing worldwide demand for electricity**
- **Tightening environmental requirements**
- **Declining R&D budgets in restructured U.S. electric industry**
- **Need flexible power generating technology:**
 - Fuel flexible(coal,oil, gas, biomass)
 - Satisfy intermediate/peak loads
 - Low life cycle operating costs
- **Maintain U.S. competitive position**



Next Generation Turbine Program

Vision: Develop advanced technologies that will significantly improve the performance, operation, and reliability of gas turbine power plants while maintaining United States industry leadership in global electric power markets. These technologies will support the continued supply of lowlife cycle cost, clean, and reliable gas turbine based power for the United States.



Program Goals

- **Reduce life-cycle cost and improve reliability, availability, and maintainability of existing and advanced turbine power plants**
- **Develop and demonstrate ultra-clean, high performance turbine power systems for near-term markets and long-term Vision 21 integration**
- **Develop critical technology to solve cross-cutting technical barriers**
- **Collaborate with agencies and develop sound technical information to produce appropriate and beneficial regulatory decisions related to gas turbine power plants**



Next Generation Turbine

Program Focus Areas

- **Advanced Systems Development and Integration**
- **Reliability, Availability, Maintainability (RAM) Improvement**
- **Cross-cutting Research and Development**



Near-Term Performance Targets

	Flexible Turbine Systems	Fuel-Flexible ATS	Turbine/Fuel Cell Hybrids
Electrical Efficiency (LHV)	15% improvement over current systems	>45% (combined cycle)	70%
Power Rating (MW)	>30	>50	<30
Fuels	Natural Gas	Coal	Natural Gas
Power Markets	Distributed/ Central Station	Central Station/ Self-Generation	Distributed

These systems will be permittable under 2010 regulations; acceptable life cycle and cost of electricity.



Long-Term Performance Targets

	Hybrids	Revolutionary Turbine Cycles
Electrical Efficiency (LHV, Gas Fueled)	75-80%	>65%
Electrical Efficiency (HHV, Coal Fueled)	>60%	60%
Power Rating (MW)	>30	>50
Power Markets	Vision 21	Vision 21

These systems will be permissible under 2015 regulations; acceptable life cycle and cost of electricity; zero emissions with carbon sequestration options.



Reliability, Availability, Maintainability Improvement

- **Condition monitoring systems and monitoring software for enhanced analysis and diagnostics**
- **Improved life Prediction Tools**
- **Aero-thermal performance and degradation models**
- **Cycle analysis; expert systems development; performance optimization**
- **Prognostics (predictions based on trend)**
- **Rotor dynamics (Vibration Analysis -Fast Fourier Transforms)**
- **Life management tools; operational optimization and life cycle cost reduction**



Cross-cutting R&D

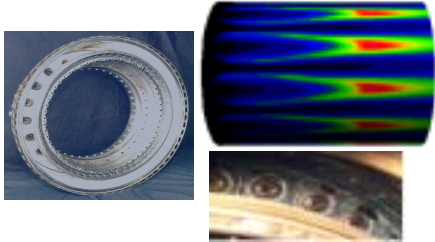
- **Robust low-emission combustion systems**
- **Materials: durable ceramics, advanced alloys, protective coatings**
- **Advanced computing**
- **High temperature sensors**
- **Diagnostics, controls, and on-line monitoring**



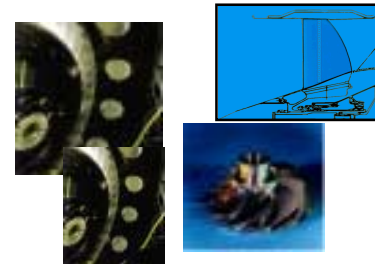
NASA/DOD/DOE Collaboration

Several Areas of Research and Testing

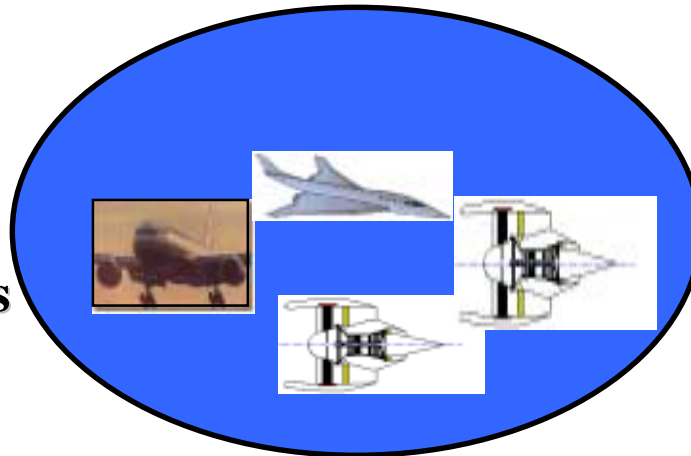
Combustion



Turbomachinery



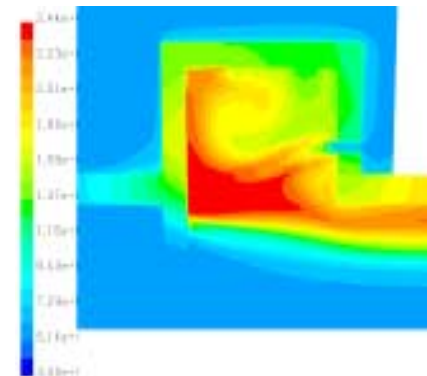
Intelligent Engines



Materials and Structures



Advanced Computing



Next Generation Turbine Program

***Projects Selected during Fiscal
Year 2000-2001***



Project Status: FY 2000-2001

- **New Projects Selected under NGT Program**

- Fabrication and Testing of an Advanced Non-Polluting Turbine Drive Gas Generator -- *Clean Energy Systems*
- Critical Components for Direct Fuel Cell/Turbine Ultra-high Efficiency System -- *Fuel Cell Energy/Capstone Turbines*
- Gas Turbine Reheat Using In-situ Combustion -- *Siemens-Westinghouse Corporation*
- Development and Testing of a Pre-Prototype Mach 2 Ramgen Engine -- *Global Power Systems*
- Small Turbo-generator Technology for Distributed Generation -- *Rolls-Royce Allison*



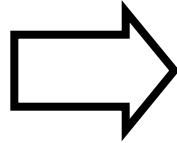
Project Status: FY 2000-2001

- **New Projects Selected under NGT Program**
 - Vision 21 Computational Workbench -- *Reaction Engineering International*
 - LES Software for Combustion System Design -- *CFD Research*
 - Feasibility and Market Studies for Next Generation Concepts:
 - *Rolls-Royce Allison*
 - *General Electric Company*
 - *Siemens-Westinghouse*
 - *Pratt and Whitney*

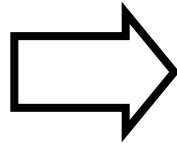


Vision: Rocket Technology Adapted For Turbine Power

**Rocket Engine
Technology**



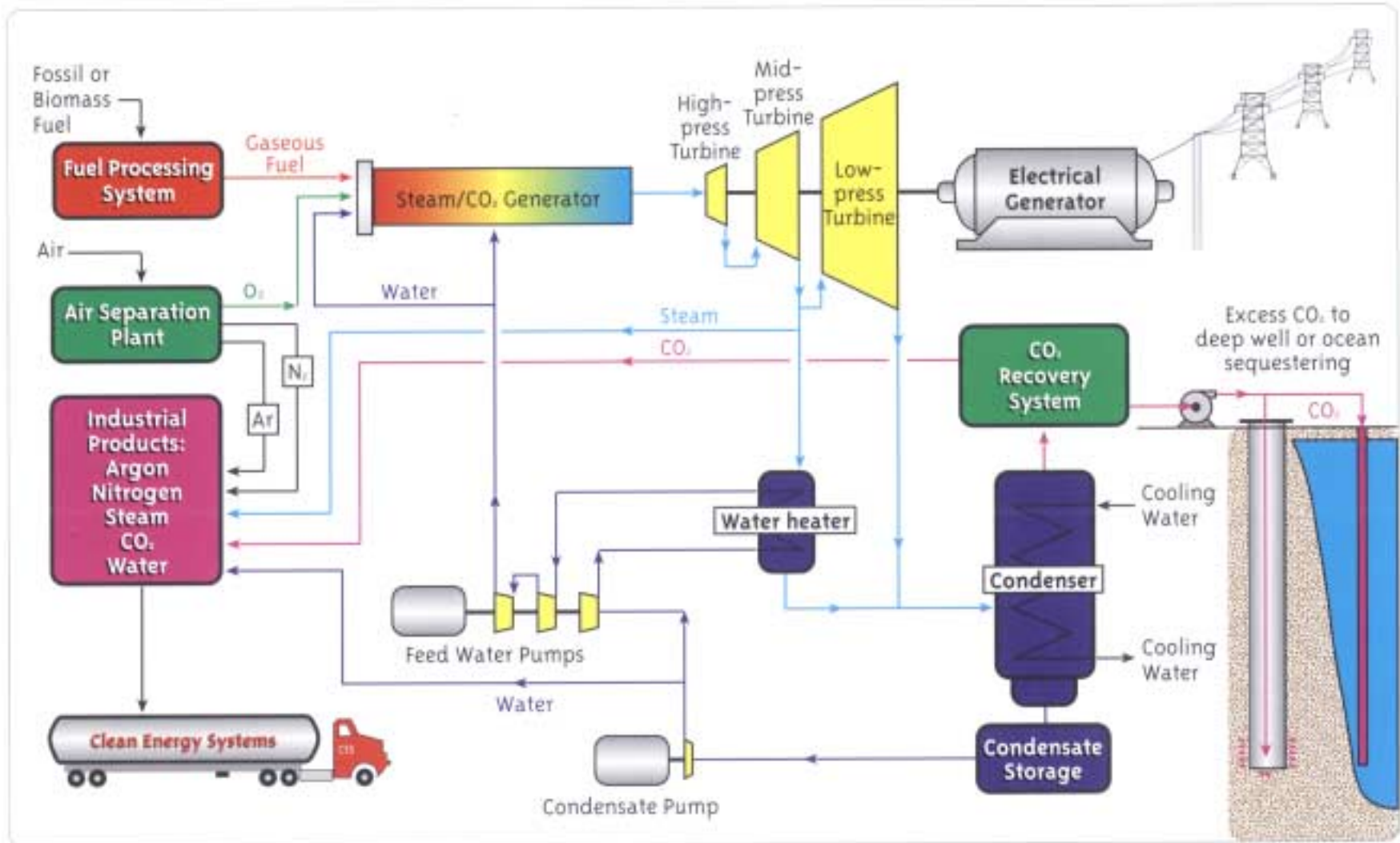
**Clean Energy
at Low Cost**



Zero-Emission Power Plants

- Low Cost Electric Power
- Easy Plant Siting
- CO₂ for Enhanced Oil Recovery
- Vision 21 Industrial Parks
- Low Cost Hydrogen Production
- Fuel Flexibility

Schematic of the CES Power System



TURBINE HYBRID POWER PLANT



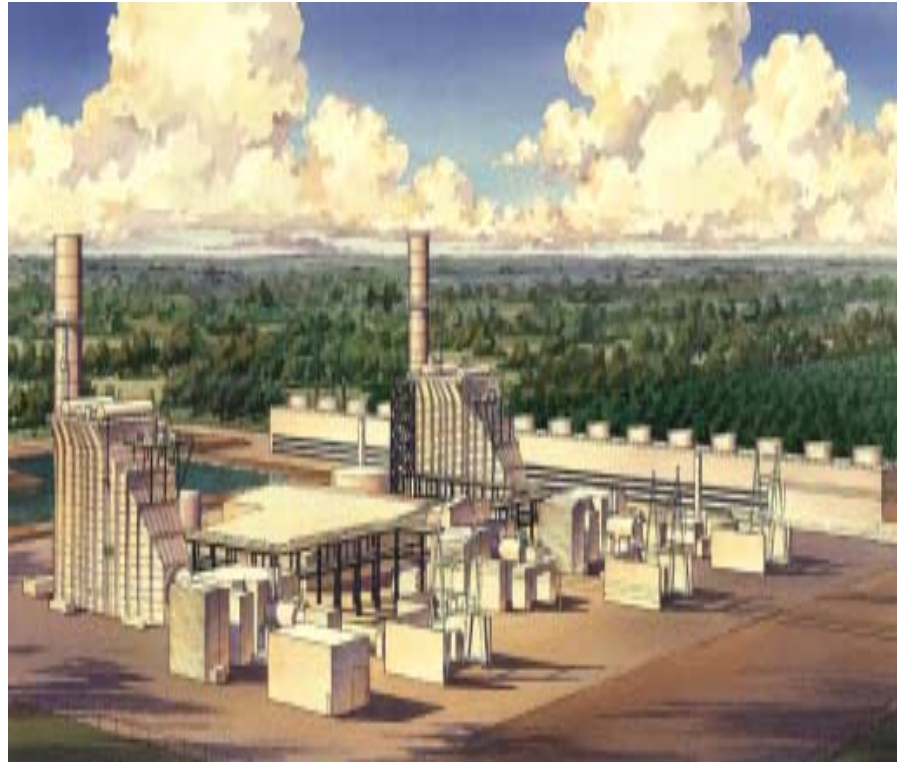
Development and Testing of a Pre-Prototype Mach 2 Ramgen Engine

- Ramjet thrust modules spin on rotor at supersonic speeds
- Fewer moving parts than IC engine
- High part load efficiency
- Low emissions(<4ppm NOx)
- Testing program ongoing with the DOE Office of Fossil Energy(NETL)



Upcoming Solicitations -- Fiscal Year 2001

- Targeted Solicitation
- Systems Design, Component Testing, and Integration
- Five to six year project



*Systems Development and
Integration*

Upcoming Solicitations -- Fiscal Year 2001

- Broad Based Financial Assistance
- Estimated Release Date - December, 2000
- Five-year projects
 - Teams to development, integrate and demonstrate advanced IT and plant operations platforms



RAM Technology Improvement



For Additional Information

WWW.NETL.DOE.GOV

